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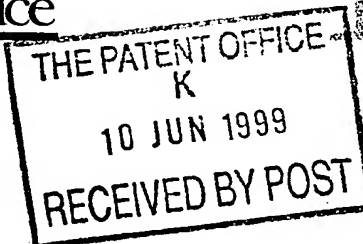
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Request for grant of a patent

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1. Your reference

0086-W

2. Patent application number

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3. Full name, address and postcode of the or of each applicant (underline all surnames)

DETROIT STEEL PRODUCTS CO., INC.

500N. Rangeline Road

P.O. Box 285

Morristown

Indiana 46161

United States of America

Indiana, USA

4/00186001 Rdes

Patents ADP number (if you know it)

If the applicant is a corporate body, give the country/state of its incorporation

4. Title of the invention

Air Suspension Anti-Roll Stabilisation System

5. Name of your agent (if you have one)

BRITTER AND CO

"Address for service" in the United Kingdom to which all correspondence should be sent (including the postcode)

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6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and (if you know it) the or each application number

Country

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Date of filing

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- a) any applicant named in part 3 is not an inventor, or
- b) there is an inventor who is not named as an applicant, or
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Yes

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AIR SUSPENSION ANTI-ROLL STABILISATION SYSTEM

DESCRIPTION

5 This invention relates to an air suspension anti-roll stabilisation system for vehicles, particularly heavy vehicles, wherein at least one pair of air bags are air spring mounted upon an axle via the suspension arms of an associated vehicle on respective opposed sides of the longitudinal axis of the vehicle, with the axle being located at least partially with respect to the frame or chassis of the vehicle by means
10 of a pair of arms which are located on respective opposed sides of the longitudinal vehicle axis and of which each has one end mounted pivotally to the vehicle frame or chassis. These longitudinal suspension arms are often made of spring steel, although they can also be fabricated from steel plates or composite materials such as reinforced plastics.

15 Generally, air suspensions are becoming more popular on vehicles, especially heavy vehicles, such as trucks and buses, to provide a low internal friction, soft ride suspension, without the large height variations associated with steel spring suspensions. Also, by using compressed air as a suspension medium,
20 the vehicle ride heights can be adjusted easily, to suit different vehicle access and operating conditions.

A popular form of air suspension is that described above.

25 Due to the soft ride and lack of internal friction, air suspension-sprung vehicles usually require considerable extra anti-roll stiffness in addition to the inherent roll stiffness provided by the transverse spacing of the air bags or other fundamental air spring units.

Most of the conventional types of air suspension systems use the resistance to roll motions built into the geometry of the system, to provide extra anti-roll stiffness. Thus, as the vehicle rolls, the axle is twisted, the arms are bent and the associated eye bushes (pivot points) are subjected to vertical forces. The respective
5 stiffness of these components of the suspension system, or their associated connections, create extra roll stiffness.

On heavier loaded axles or softer sprung suspensions, this arrangement provides insufficient stiffness or strength to withstand heavier loads, the limitation
10 often being the bending strength or stiffness of the longitudinal suspension arms or the load stress levels at the rigid connections of the axle thereto. In applications which use those arms to locate the axle laterally, the axle connections also have to withstand high transverse bending moments in addition to the anti-roll forces.

Therefore, in many air suspension systems, extra and separate but conventional stabiliser bar systems are required, to provide adequate vehicle anti-roll stability. These additional systems involve considerable additional weight and costs.
15

Accordingly, it is an object of the present invention to provide an air suspension anti-roll stabilisation system which overcomes, or at least substantially reduces, the disadvantages associated with the known types of system discussed above and which provides a low cost and weight design for incorporating anti-roll stiffness in those known systems.
20

Accordingly, the present invention is directed to an air suspension anti-roll stabilisation system of the type discussed above but wherein anti-roll means, such as an anti-roll bar or tube, is connected rigidly between the pair of longitudinal suspension arms, preferably at or adjacent the points at which the one end of each
25

arm is pivotally attached to the frame or chassis of the associated vehicle.

5 In this manner, the anti-roll means, which extends transversely of the longitudinal axis of the associated vehicle, has the effect of adding bending stiffness to the longitudinal suspension arms during vehicle roll. When the opposed ends of the anti-roll means are connected rigidly to the longitudinal suspension arms at or adjacent the respective pivot points thereof, such an arrangement adds transverse, torsional stiffness close to those pivot points.

10 Thus, the arrangement of this inventive air suspension anti-roll stabilising system converts the longitudinal suspension arms upon which the air bags or other air suspension units are mounted, from acting as beams which are pivotally mounted at their one ends to the frame or chassis of the vehicle, to beams which are fixed or tending towards "encastre" at those one ends, during roll motion of the vehicle. This stiffens the arms in bending, whilst also assisting in the reduction of the resultant bending stresses in those arms.

20 During vehicle roll, the associated pivot points rotate in opposite directions, whilst in normal, straight axle ride, they rotate in the same direction. Thus, even if there is a rigid torsional connection between the longitudinal suspension arms, they retain the pivotal freedom during such normal ride motion. The difference between the fixed end and pivotally jointed deflections of the longitudinal suspension arms, and the degree of torsional stiffness in the components which interconnect those arms, create the required additional anti-roll resistance during roll deflections.

25 In order that the inventive air suspension anti-roll stabilisation system may be more fully understood, preferred embodiments in accordance therewith will now be described by way of example and comparison with prior art systems and with reference to the accompanying drawings in which:

Figures 1A, 1B and 1C are respective side, end elevational and plan views of a first form of prior art air suspension system;

5 Figures 2A and 2B are respective side elevational and plan views of a second form of prior art air suspension system;

 Figure 3A and 3B are respective side elevational and plan views of a first embodiment of inventive air suspension anti-roll stabilisation system;

10 Figure 4A and 4B are respective side elevational and plan views of a second embodiment of inventive air suspension anti-roll stabilisation system;

 Figures 5A and 5B are respective side and end diagrammatic representations of the movement and stresses in one of the longitudinal suspension arms of the prior art air suspension systems of Figures 1 and 2, under compression and extension thereof;

15 Figure 6A and 6B are respective side and end diagrammatic representations of the deflection and moment forces of one of the longitudinal suspension arms of the inventive air suspension systems shown in Figures 3 and 4, again under compression and extension thereof; and

20 Figure 7A is a bending moment diagram for the longitudinal suspension arms of the second form of prior art and inventive air suspension systems of respective Figures 2 and 4 under static load;

25 Figures 7B and 7C are respective bending moment diagrams for the longitudinal suspension arms of both forms of prior art and inventive air suspension

systems of respective Figures 2 and 4 under roll conditions;

Figure 8A and 8B are side elevational views of prior art air suspension systems;

5 Figure 9A and 9B are respective side elevational and plan views of a third embodiment of inventive air suspension anti-roll stabilisation system;

10 Figure 10A and 10B are respective side elevational and plan views of a fourth embodiment of inventive air suspension anti-roll stabilisation system;

 Figure 11A is a plan view of a fifth embodiment of inventive air suspension anti-roll stabilisation system, Figure 11B and 11C are respective side elevational views along lines B'-B and A'-A, and Figure 11D is a plan view of Figure 11C;

15 Figure 12A is a side elevational view of a sixth embodiment of inventive air suspension anti-roll stabilisation system.

20 Referring firstly to Figures 1A, 1B and 1C, here there is illustrated a prior art air suspension system, indicated generally at 11 and comprising a pair of air bags 12 which are mounted fixedly at 14 to an axle 13 of an associated vehicle on respective opposed sides of the longitudinal axis thereof. The axle 13 is located longitudinally of the frame or chassis 15 of the vehicle by means of the pair of arms 16 which are also located on respective opposed sides of the longitudinal vehicle axis and which extend between the respective air bags 12 and the axle 13, also
25 mounted fixedly thereto at 14.

 One end 17 of each longitudinal suspension arm 16 is pivotally mounted at 18 to the vehicle frame 15, or chassis by means of eye bushes (pivot points) 18 attached to a vertical plate or other member 19 which, in turn, is attached rigidly to

the vehicle chassis or frame 15.

To the other end 20 of one of the longitudinal suspension arms 16, is pivotally attached, at 21, one end of a lateral location rod 22 whose other end is pivotally attached, at 23, to the vehicle frame or chassis 15 via a vertical bracket 24.

Connected between the axle 13 and vehicle frame or chassis 15 is a generally U-shaped stabilising or anti-roll member 25, in known manner. Each arm of the member 25 comprises a generally horizontal portion 26 and a generally vertical portion 27. The base 28 of the U-shaped member 25 is attached pivotally to the axle 13 at locations 29, with the generally horizontal portion 26 thereof being connected pivotally at 30 to the lower end of the generally vertical portion 27, whose upper end 31 is, in turn, connected pivotally at 31 to the vehicle frame or chassis 15.

15

The prior art air suspension system described above in relation to Figures 1A to 1C, has particular application as a suspension system at the forward end of a vehicle, wherein the longitudinal suspension arms 16 are often made of spring steel but can also be fabricated from steel plates.

20

In Figures 2A and 2B, there is shown another prior art air suspension system for particular application at the rear end of a vehicle, which comprises a pair of air bags 42 which are mounted upon an axle 43 of an associated vehicle on respective opposed sides of the longitudinal axis thereof, with the axle 43 being located transversely of the frame or chassis 45 of the vehicle by means of a pair of arms 46 which are also located on respective opposed sides of the longitudinal vehicle axis and of which each has one end 47 mounted pivotally at 48 to the vehicle frame or chassis 45 and via a generally vertical bracket 49 whose upper end is secured rigidly to the vehicle frame or chassis 45.

25

The other end 47' of each longitudinal suspension arm 46 has mounted thereupon the corresponding air bag 42, whilst intermediate those arm ends 47, 47' and generally centrally of the arm 46, is secured rigidly the axle 43 by means of a two-part axle clamp 44, 44'.

A seating 44" for the longitudinal suspension arm 46 is associated with the lower part 44' of the axle clamp.

As already discussed above, because some of the prior art air suspension systems have a soft ride and lack of internal friction, the associated air suspension sprung vehicles usually require considerable extra anti-roll stiffness in addition to the inherent roll stiffness provided by the transverse spacing of the air bags or other fundamental air spring units.

Typically, the prior art air suspension systems described above in relation to Figures 1A to 1C and Figure 2A and 2B, respectively, use the resistance to vehicle roll motions built into the geometry of the system, to provide at least some extra anti-roll stiffness. Thus, as the associated vehicle rolls, the axle 13,43 is twisted, the longitudinal suspension arms 16,46 are bent and the pivot point 18,48 (eye bushes) at the one end of each arm 46 is subjected to vertical forces. The respective stiffness of these components of the prior art air suspension systems, as well as their associated mechanical connections, provide at least some extra roll stiffness.

With heavier loaded axles 13,43 or softer sprung suspensions, this extra anti-roll stiffness can be insufficient to withstand such loads. Such limitation is often provided by the bending strength or stiffness of the arms 16,46 or the local stress levels at the connections of the axles 13,43 thereto. In particular applications where the arm 46 locate laterally the axle 43, the associated axle connections also

have to withstand high transverse bending moments in addition to the anti-roll forces when not using a lateral location rod such as that shown at 22 in Figures 1A to 1C.

5 Therefore, in some prior art air suspension systems, additional but separate conventional stabiliser means, such as an anti-roll bar or tube, is required to provide adequate anti-roll stability for the associated vehicle. Such a prior art system has been described above in relation to Figures 1A to 1C, wherein the generally U-shaped stabiliser (anti-roll means) is provided. However, these extra
10 but separate and preformed stabiliser or anti-roll means add considerable weight and cost to the prior art air suspension systems.

 In order to overcome, or at least substantially reduce, these disadvantages associated with prior art air suspension systems, there is provided an inventive air
15 suspension system, such as that shown in Figures 3A and 3B, wherein anti-roll means, such as an anti-roll bar or tube, is connected rigidly between the pair of longitudinal suspension arms, preferably at or adjacent the points at which the ends of the arms are attached pivotally to the chassis or frame of the associated vehicle.

20 Thus, such an improved air suspension system in accordance with the invention will now be described with reference to Figures 3A and 3B.

 Here, the inventive system 51 is similar to the prior art air suspension system 11 described above in relation to Figures 1A to 1C, in that it comprises a
25 pair of air bags 52 which are mounted upon an axle 53 of an associated vehicle on respective opposed sides of the longitudinal axis thereof, with the axle 53 being located transversely of the vehicle frame or chassis 55 by means of a pair of arms 56 which are located also on respective opposed sides of the longitudinal vehicle axis and of which each has one end 57 mounted pivotally, for example, by means of

an eye bush 58, to the vehicle frame or chassis. Again, a lateral location rod 62 is provided, as in the case of the first prior art air suspension system described above.

5 However, the inventive air suspension system 51 does not include the add-on, separate and preformed anti-roll means 25 of the first form of prior art air suspension system, which, in that system 11, is clamped pivotally between the vehicle frame or chassis 15 and the axle 13.

10 Instead, a torsional inter-arm connection, in the form of an anti-roll bar or tube 65 is provided. That anti-roll bar or tube 65 is, in accordance with the invention, connected rigidly between the pair of longitudinal suspension arms 56, at or adjacent the pivot points (eye bushes) 58 at which the ends 57 of the arms 56 are attached pivotally to the chassis or frame of the associated vehicle.

15 In this manner, the anti-roll means 65, which extends transversely of the longitudinal axis of the associated vehicle, has the effect of adding bending stiffness to the longitudinal suspension arms 56 during vehicle roll. When the opposed ends of the anti-roll bar or tube 65 are connected rigidly to the longitudinal suspension arms 56 at or adjacent the respective pivot points 58, such an arrangement, in
20 accordance with the invention, and as described above in relation to the first embodiment of air suspension system of Figure 3A and 3B, adds transverse, torsional stiffness close to those pivot points 58.

25 The anti-roll bar or tube 65 of the inventive air suspension system described above with reference to Figure 3A and 3B, may be of any suitable section, for example, circular or square.

Referring to Figures 4A and 4B, there is shown a second embodiment of inventive air suspension system 71 which is similar to the second form of prior art

air suspension system 41 described above with reference to Figure 2, in that it comprises a pair of air bags 72 mounted upon an axle 73 of an associated vehicle on respective opposed sides of the longitudinal axis thereof. The axle 73 is located transversely of the vehicle frame or chassis 75 by means of a pair of arms 76 which are located on respective opposed sides of the longitudinal vehicle axis and of which each has one end 77 mounted pivotally at 78, for example, by means of an eye bush, to the vehicle frame or chassis. As in the case of the second prior art air suspension system 41 described above in relation to Figure 2, this second embodiment of air suspension system 71 has the one end 77 of each longitudinal suspension arm 76 mounted pivotally to the vehicle frame or chassis 79 by means of, firstly, an eye bush 78 which, in turn, is mounted to a generally vertical bracket 80 whose upper region is secured firmly to the vehicle frame or chassis 79.

Similarly, also, each air bag 72 is mounted between the vehicle frame or chassis 79 and the other end 77' of the longitudinal arm 76 thereupon, with the axle 73 clamped securely to an intermediate part of each arm 76 by means of a two-part clamp 74, 74'.

However, this second embodiment of inventive air suspension system 71 is provided with stabilising or anti-roll means in the form of a square cross-sectioned anti-roll bar or tube 75 which is connected rigidly between the pair of longitudinal suspension arms 76 at or adjacent the pivot points (eye bushes) 78 at which the one end of each arm 76 is attached pivotally to the vehicle frame or chassis 79.

As in the case of the first embodiment of inventive air suspension system described above in relation to Figure 3, this anti-roll means, in the form of the anti-roll bar or tube 75, which extends transversely of the longitudinal axis of the associated vehicle, has the effect of adding bending stiffness to the longitudinal suspension arms 76 during vehicle roll. When opposed ends of the anti-roll means

75 are connected rigidly to the longitudinal suspension arms 76 at or adjacent the respective pivot points 78, such arrangement also adds transverse, torsional stiffness thereat or close thereto but not under normal axle ride motion.

5 In Figure 5A, a longitudinal suspension arm of each prior art air suspension system 11,41 is shown in the rest or normal position of the suspension system at 16,46 and in the compressed and extended positions thereof, when the suspension system 11,41, is subject to roll motions of the associated vehicle, at 16',45' and 16" and 46", respectively. The corresponding transverse end view of a pair of
10 longitudinal suspension arms is shown in Figure 5B, with the axle shown diagrammatically at 13,43 and the suspension arms 16,46 at opposed ends thereof.

 In these prior art arrangements, the resistance to roll motions built into the geometry of the air suspension systems 11,41, is shown by respective arrows A and
15 B in compression and extension of the system, respectively.

 Thus, as the vehicle rolls, the axle 13,43 is twisted and the longitudinal suspension arms 16,46 are bent and the eye bushes 18,48 are subjected to vertical forces. The respective stiffness of these components of the prior art suspension
20 systems 11,41, and/or their associated connections, create extra roll stiffness.

 However, on heavier loaded axles or softer sprung suspensions, this arrangement has insufficient stiffness or strength to withstand such heavier loads. This limitation is often the bending strength or stiffness of the arms 16,46 or the
25 local stress levels at the corresponding axle connections. On applications which use the arms 16,46 to locate the axle laterally with respect to the vehicle, the axle connections also have to withstand high transverse bending moments in addition to the anti-roll forces.

With the presently inventive air suspension systems 51,71, additional transverse, torsional stiffness is provided by the anti-roll means, such as the anti-roll bar or tube 65,75 discussed above in relation to Figures 3 and 4, which is connected rigidly between the pair of longitudinal suspension arms 56,76. Thus, such an inventive arrangement, with the longitudinal suspension arms 56,76 in positions corresponding to those shown and discussed above in relation to the prior art suspensions 11,41 of Figures 5A and 5B, namely, in compression and extension at 56', 76' and 56", 76", respectively, an additional torsional resistance is provided for the suspension 51,71, as indicated by the arrows C and D respectively, as shown in Figures 6A and 6B.

Figure 7A is a bending moment diagram for the arms 46 and 76 between the pivot points 48 and 78 and the respective axles 43 and 73, the corresponding bending stress in each of the longitudinal suspension arms 46 and 76 of the prior art and inventive suspension systems 41 and 71 at static load being shown by the line graph E.

In Figure 7B, which is a bending moment diagram for the arms 46 of the prior art suspension system 41 between the pivot points 48 and the angle 43, that static bending stress is also shown by the graph E but for the prior art suspension system 41, the corresponding bending stresses under compression and extension at normal, moderate roll conditions of the associated vehicle are shown at F and G, respectively.

In Figure 7C, which is a bending moment diagram for the arms 46 and 76 between the pivot points 48 and 78 and the respective angles 43 and 73, of both the prior art and inventive suspension systems 41 and 71, the corresponding bending stresses for static and normal moderate roll conditions for the prior art system 41 are again shown at E, F and G. However, with the inventive suspension systems 71

the corresponding line graphs of the bending stresses in the longitudinal suspension arms 76 under compression and extension, are shown by the line graphs H and I, respectively.

5 Thus, it can be seen that in inventive air suspension systems, the provision of the anti-roll means connected between the longitudinal suspension arms at or adjacent the associated pivot points (eye bushes) converts the arms from acting as beams which are jointed pivotally to the vehicle frame or chassis, as in the prior art suspension systems 11,41, discussed above, to beams which are fixed or encastre
10 during roll motions of the vehicle. In this manner, the longitudinal suspension arms 56,76 of the inventive air suspension systems 51,71 are stiffened in bending, thereby assisting in the reduction of associated bending stresses in those arms.

15 As discussed above, during roll motions of the associated vehicle, the pivot points rotate in opposite directions and in normal straight axle ride, they rotate in the same direction. Thus, even if there is a rigid torsion connection between the longitudinal suspension arms, such as that provided by the inventive suspension systems, the arms retain their pivotal freedom during this normal ride motion.

20 As can be seen from the line graphs of Figure 7C, the difference between the fixed end and pivotally jointed deflections of the longitudinal suspension arms, and the degree of torsional stiffness in the components which interconnect the arms, create additional anti-roll resistance, during roll motions of the vehicle and corresponding deflections of the suspension systems and reduce the bending
25 stresses in the arms.

Referring now to Figures 8A and 8B, two alternative prior art suspension systems are shown. Each system comprises a pair of air bags 82 (only one of each shown) which are mounted upon one end 84' of an air suspension arm 86. The arm

86 has mounted pivotally thereon, at its other end 84, a frame bracket 89. The pivot point 88 comprising an eye bush. Intermediate the arm ends 84, 84' and generally central of the arm 86, an axle 83 of an associated vehicle is secured thereto.

5 In Figure 8A, the axle 83 is secured to the arm 86 by a bracket 87 connected to the arm at two axle bushes 81. Figure 8B shows an axle 83 secured to the arm 86 by a bracket 87' at one axle bush 81'. The axle is further provided with an upper axle control arm 85 to afford the vehicle extra stability under braking or traction.

10

 Referring to Figures 9A and 9B, a suspension arm 96 commensurate with the invention is shown. The suspension arm 96, which may be attached to the axle in the manner shown in either Figure 8A or 8B, is provided with an anti-roll bar or tube 95 at an end 94 of the arm 96. The bar or tube 95 may be located at various
15 locations, indicated at 95', 95'' and 95'''. Positioning the anti-roll bar at the end 94 of the suspension arm affords the suspension greater anti-roll stiffness and stability.

 Figures 10A and 10B show a further embodiment of inventive arrangement wherein the anti-roll bar or tube 105 is coaxial with the pivot point 108 of the suspension arm 106 and is rigidly secured to the arm 106. The bracket 109, through
20 which the arm 106 is attached pivotally to the chassis or frame of the vehicle, is provided with a through bore that accommodates the bush. The anti-roll bar 105 protrudes through the bracket 109 and is clamped in place by a two part bracket 110, comprising upper 101 and lower 102 portions held together by suitable means
25 such as nuts and bolts.

 Referring to Figures 11A to 11D, the U-shaped ends 124 of a pair of spring arms 126 are shown. An anti-roll bar or tube 125 is clamped into the U-shaped portion 124 by virtue of a clamping bracket 127 with upper 127' and lower 127''

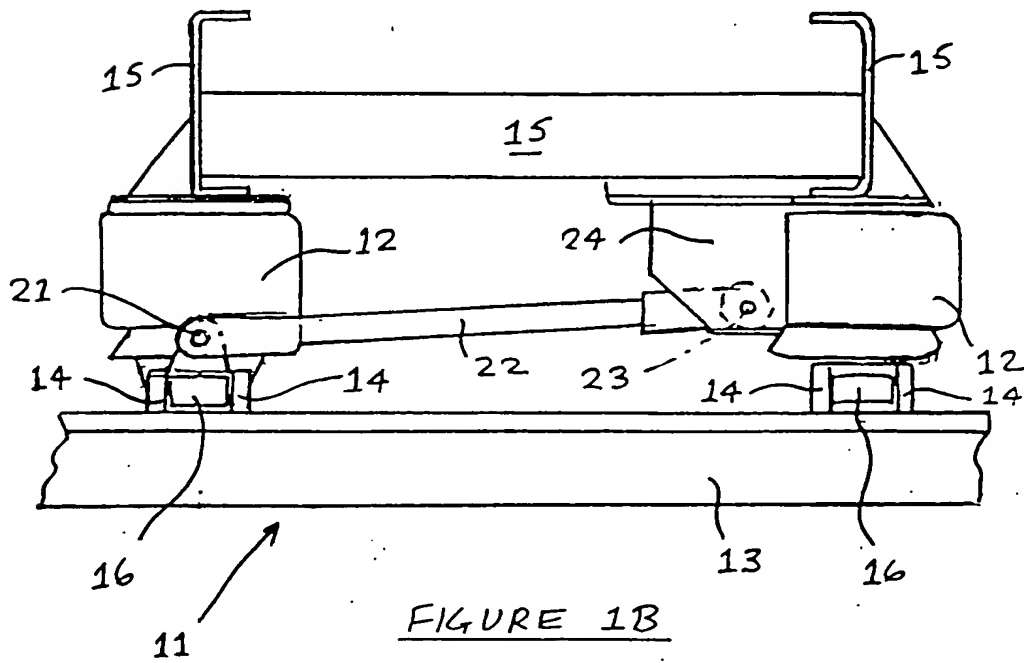
portions. The upper portion 127' fits into the U-shaped end 124 of the spring arm and is provided with a transverse through bore to accommodate the anti-roll bar or tube 125. The upper portion 127' is further provided with a vertical through bore to accept the thread of a bolt, and has also a horizontal split in a direction running from the transverse through bore longitudinally toward the centre of the spring arm 126. The opposed legs of the U-shaped portion 124 is provided with vertical through bores which mate with the vertical bore of the upper portion 127'. A bolt is placed through the mating vertical bores and thereby protrudes dependently from the lower leg of the U-shaped portion of the spring arm 126. The lower portion 127'' is also provided with a through bore through which the depending portion of the bolt is placed. A nut is then used to clampingly secure the anti-roll bar 126 in place in the U-shaped portion 124 of the spring arm 126. A further U-shaped bracket, or U-bolt, 130 is utilised to rigidly clamp the upper 127' and lower 127'' portions of the clamping bracket 127.

Referring to Figure 11B, the vertical bracket 129 is provided with a pivot point 128 (an eye bush) through which it is connected to the anti-roll bar or tube 125. The bracket 129' may alternatively be located internally of the spring arm 126 to thereby reduce the width of the suspension system.

Figure 12 shows an alternative way of clamping the spring arm 136, wherein a bracket 137 supports the anti-roll bar or tube 135. A U-shaped clamping member 140 clamps the anti-roll bar or tube 135, through apertures in the spring arm 135, to a lower bracket portion 137' where it is held in place by virtue of nuts which engage threaded portions of the clamping member 140. Alternatively, a pair of members 140 may secure the tube 135 to the arm such that each is disposed about opposite sides of the arm 135 and clamps to a lower bracket portion 137'.

All of the inventive embodiments may be used on suspension systems which

are utilised in either front or rear wheel suspension systems and all provide a low weight method of increasing the stability of air suspension systems whilst providing improved ride characteristics.



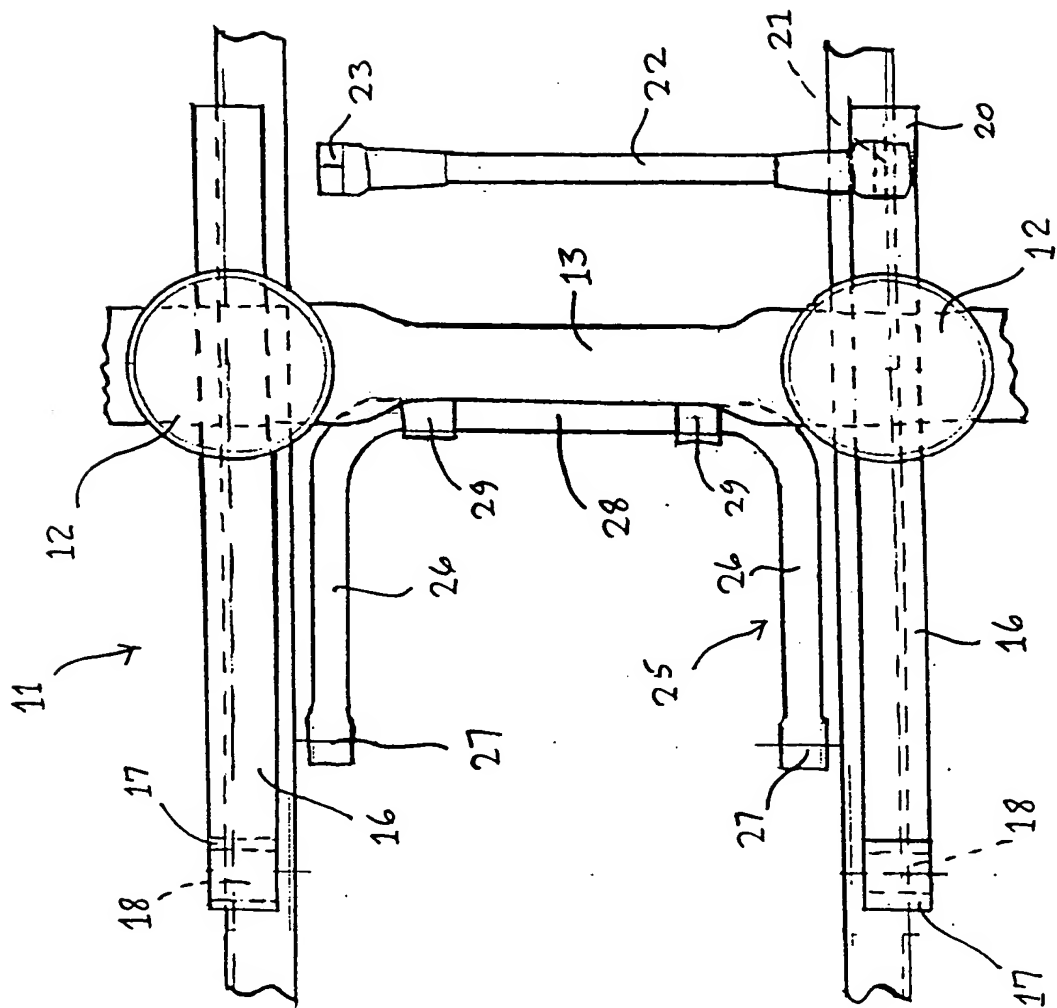


FIGURE 1C

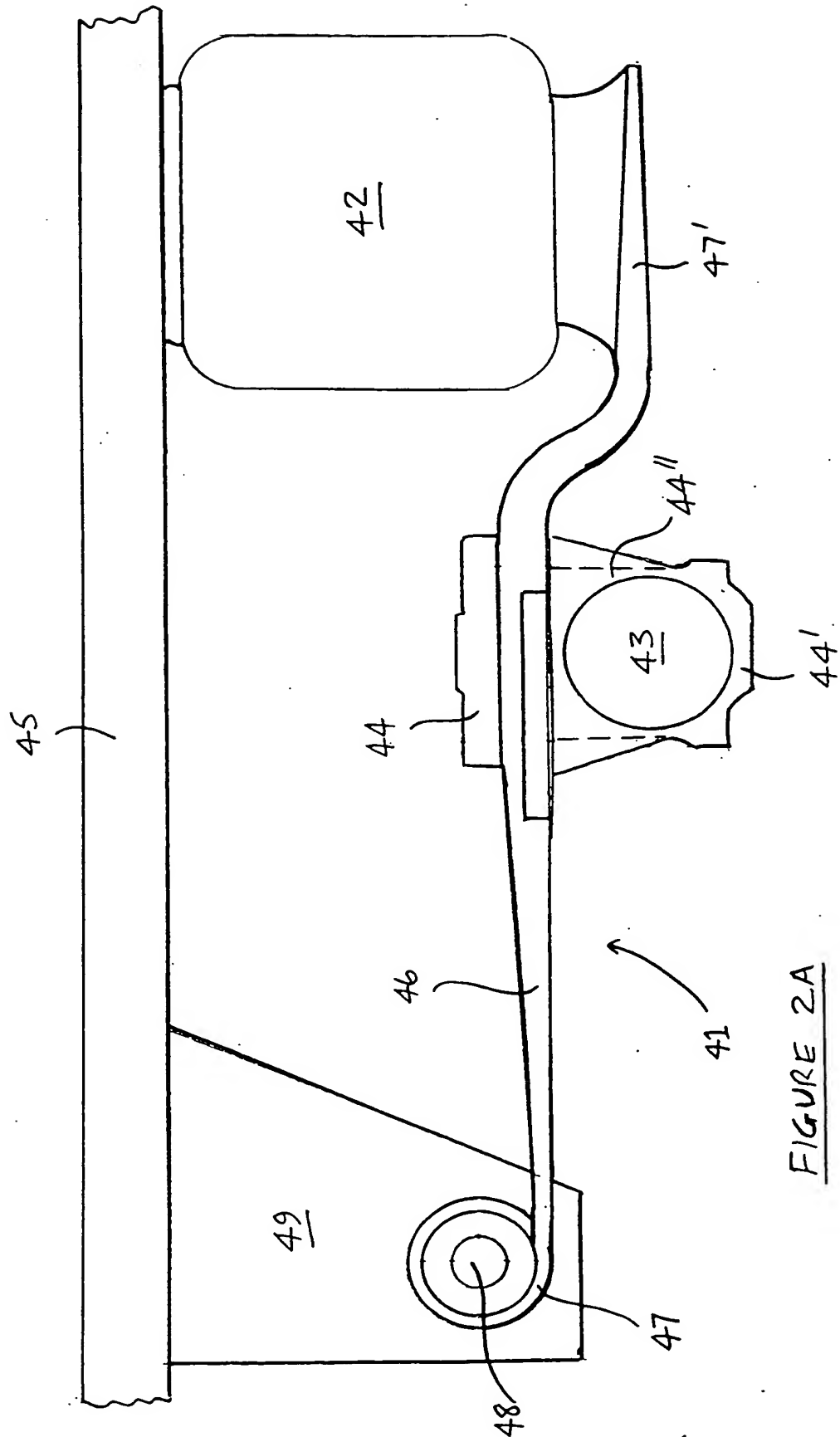
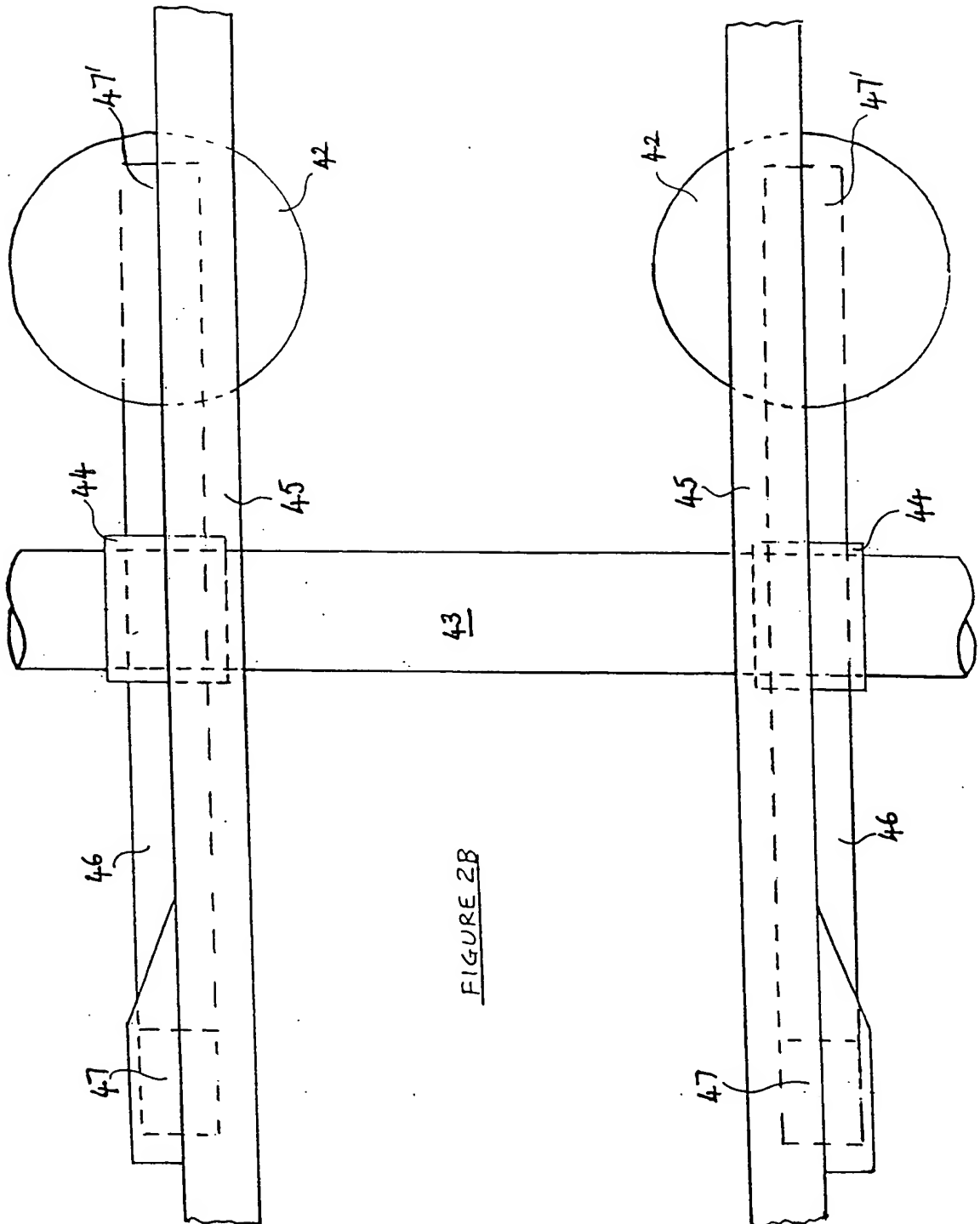


FIGURE 2A



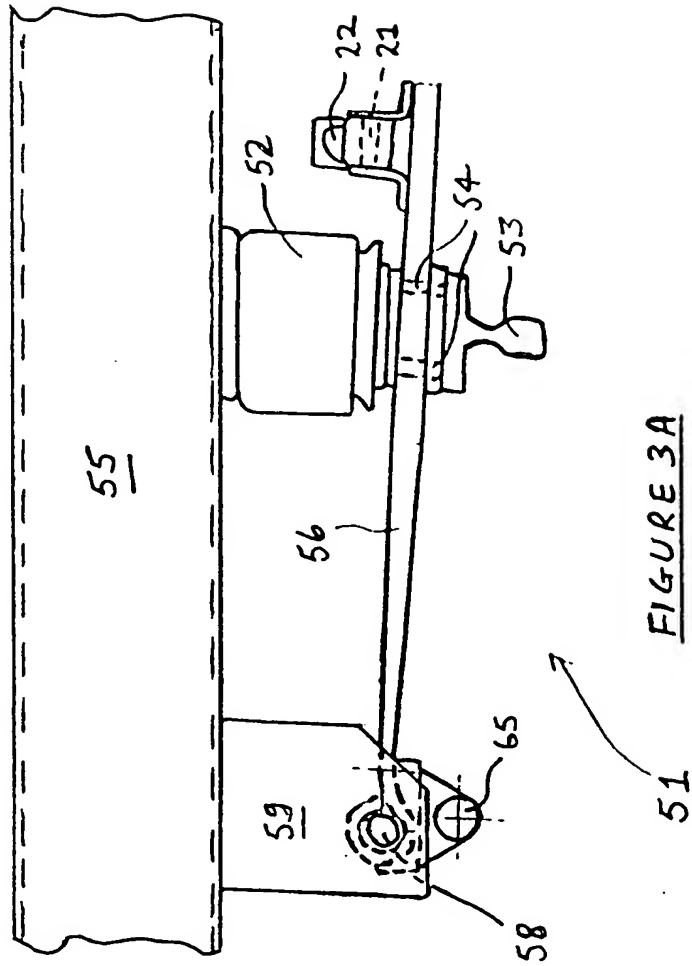
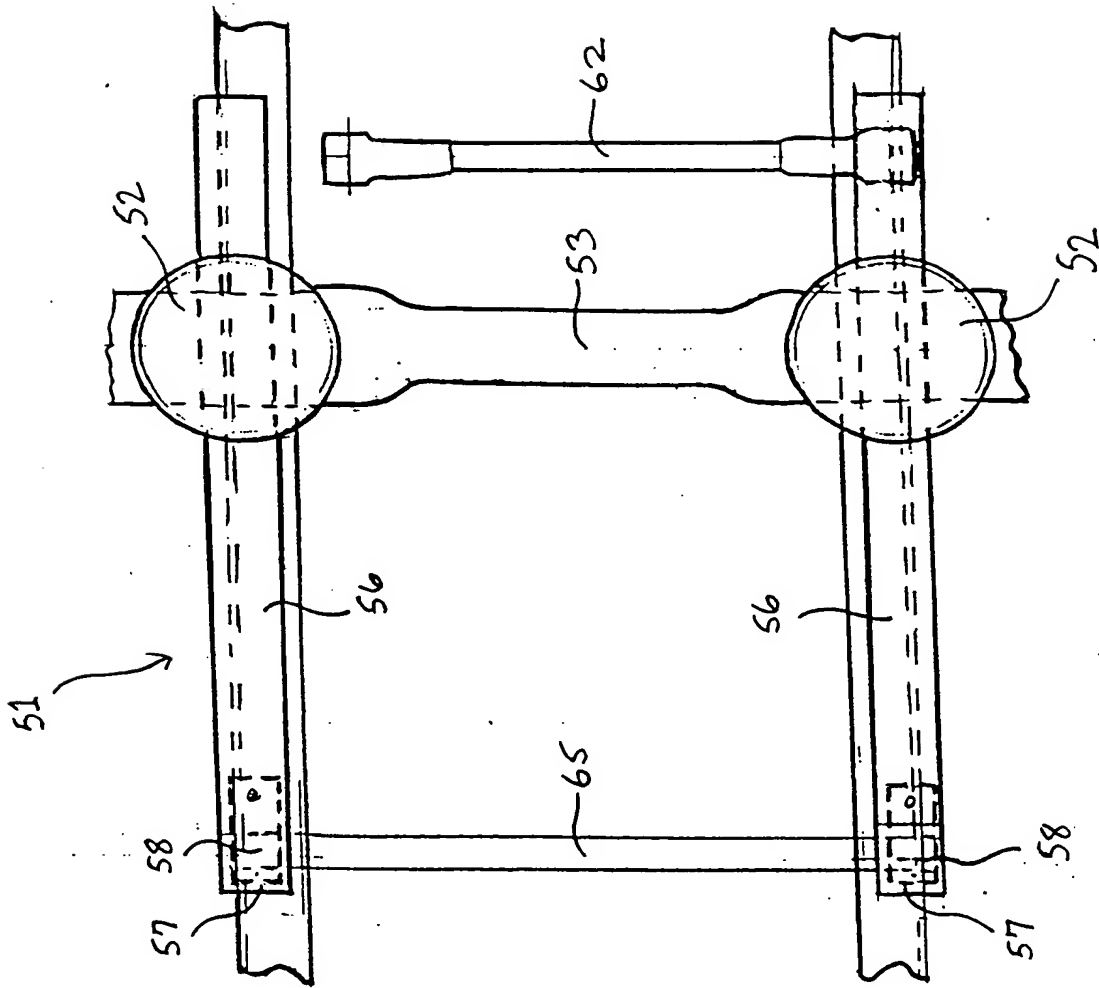


FIGURE 3B



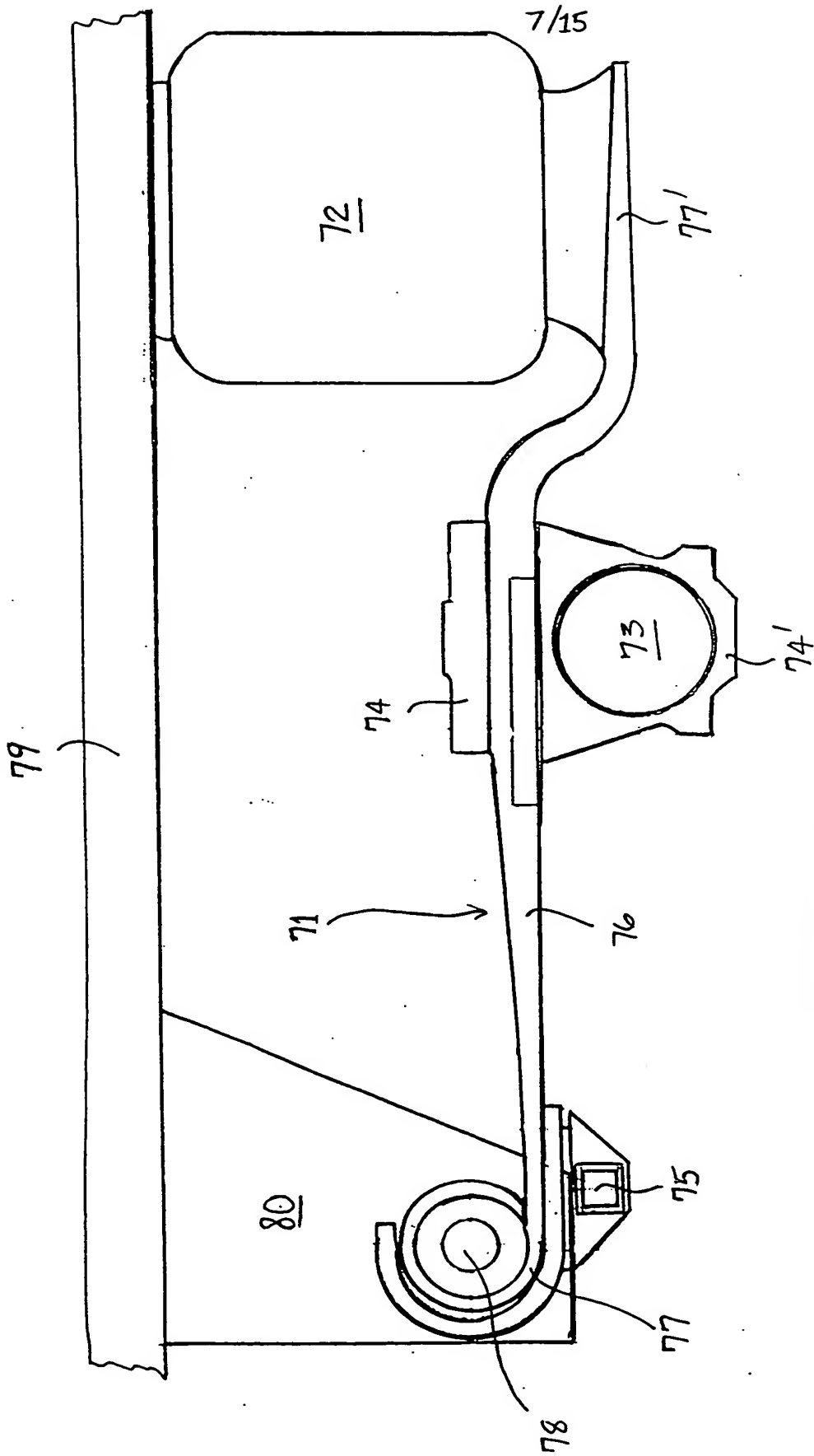
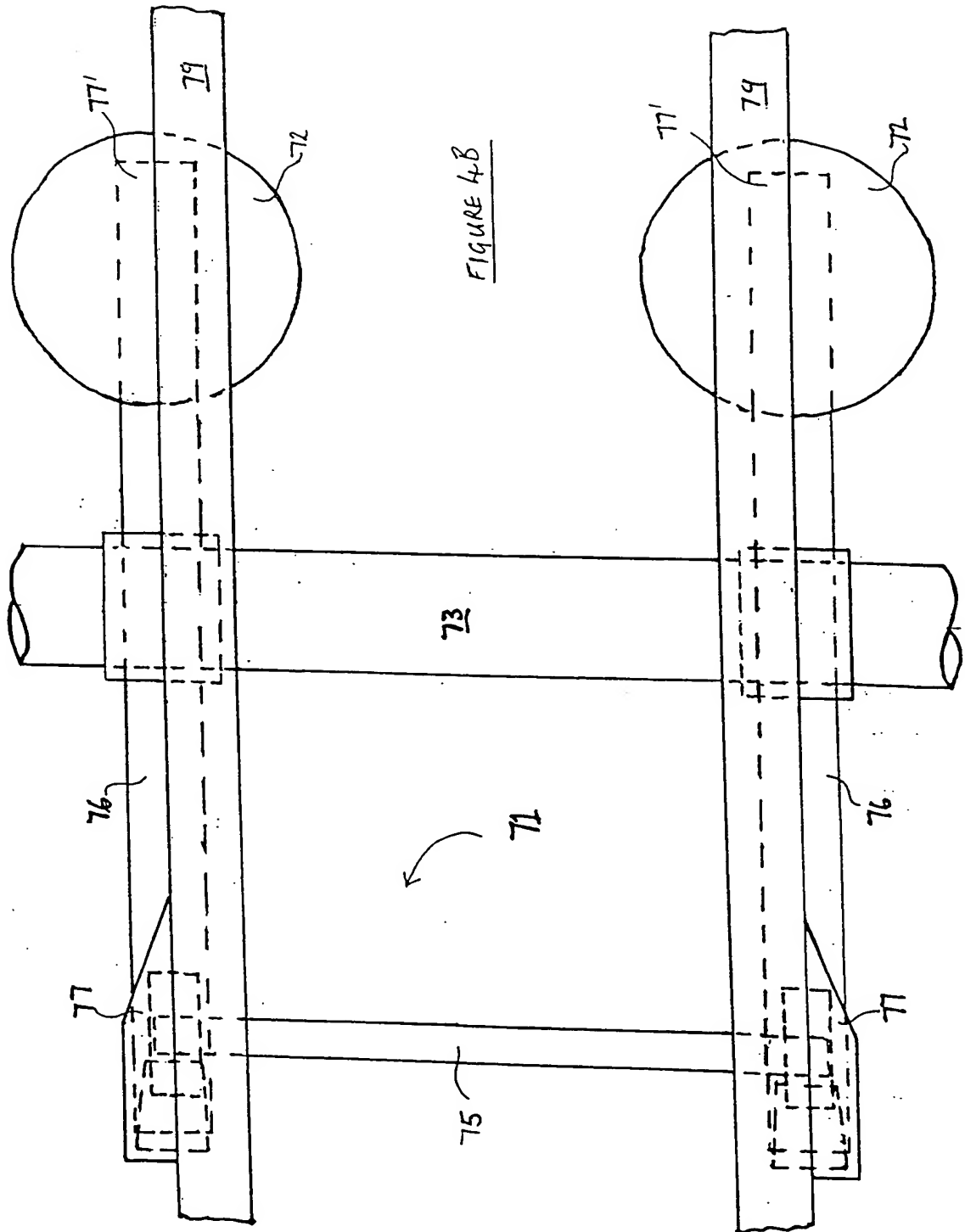


FIGURE 4A

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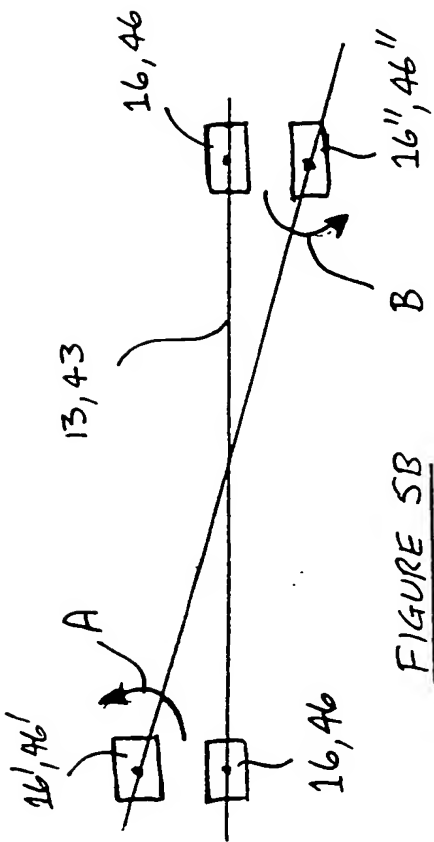


FIGURE 5B

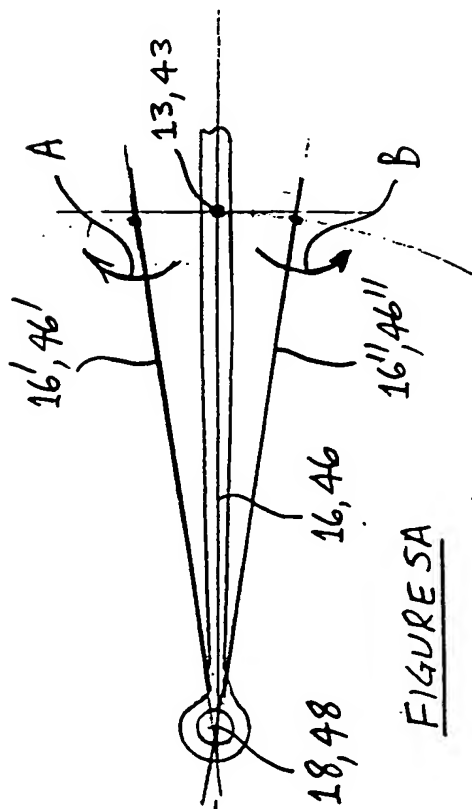


FIGURE 5A

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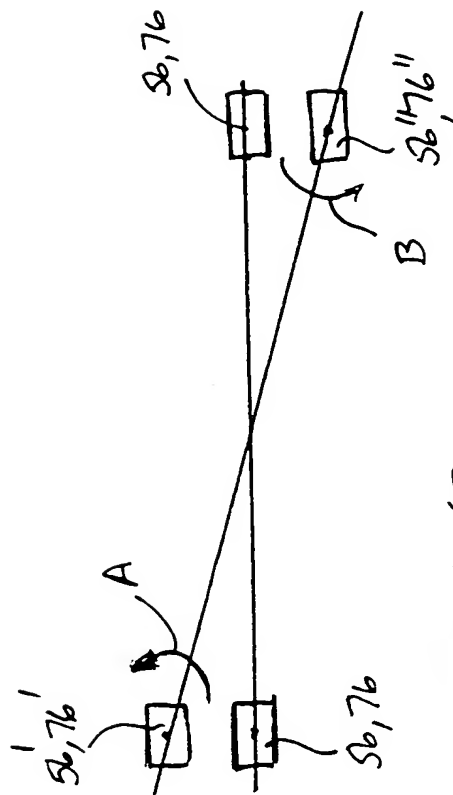


FIGURE 6B

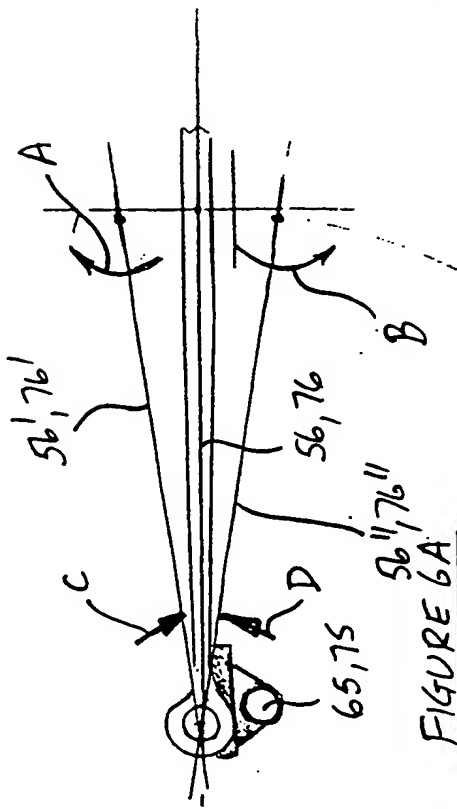


FIGURE 6A

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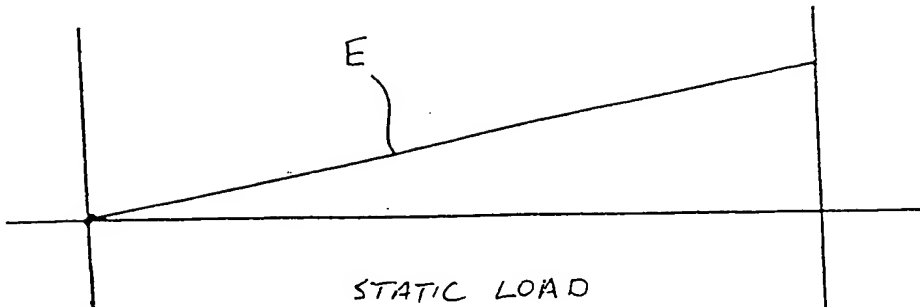


FIGURE 7A

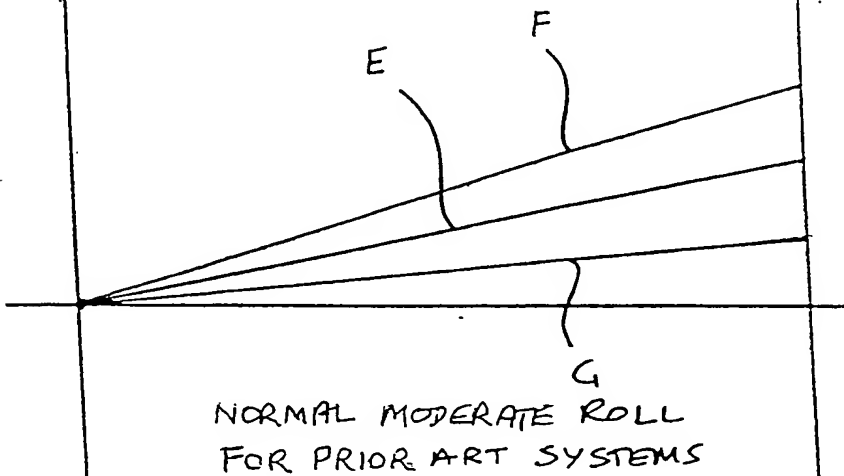


FIGURE 7B

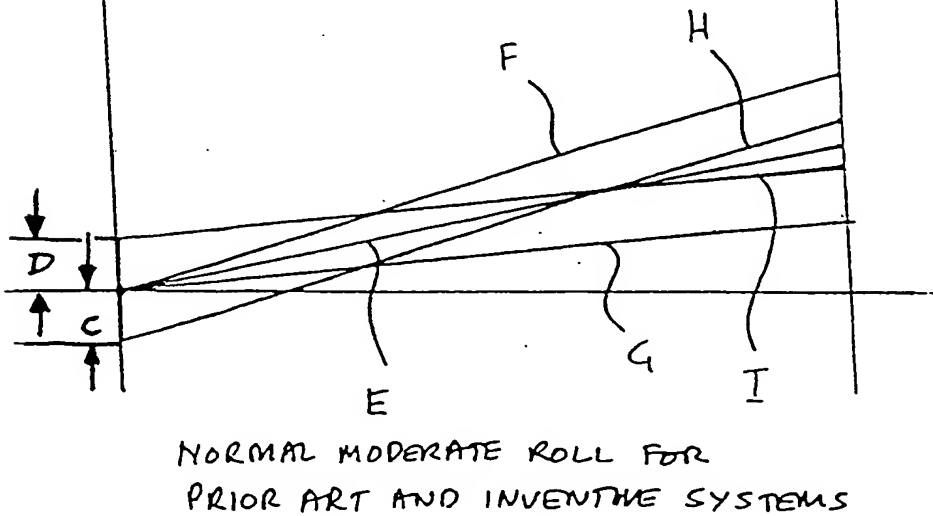


FIGURE 7C

FIGURE 8A

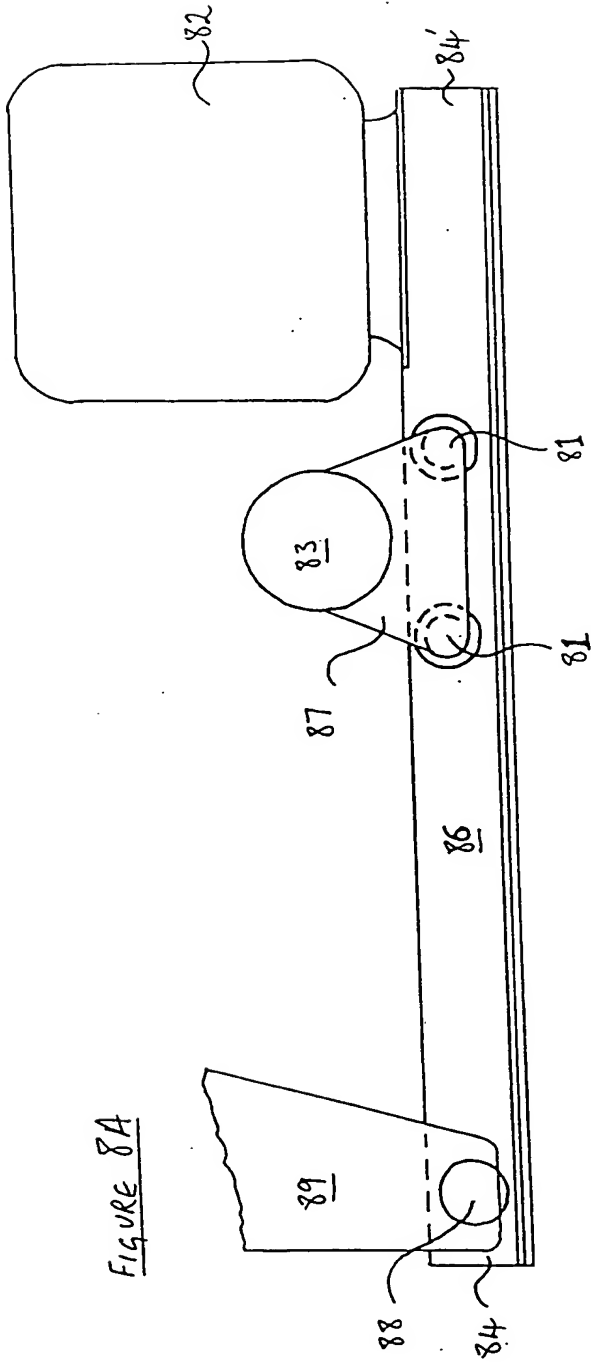


FIGURE 8B

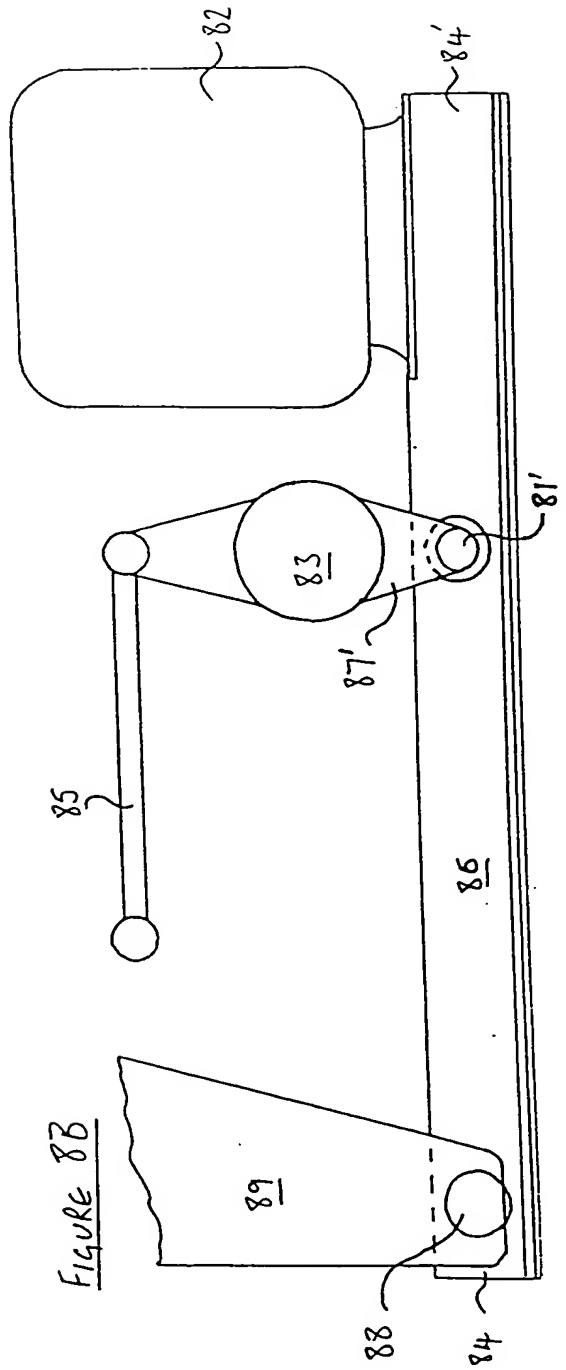


FIGURE 9A

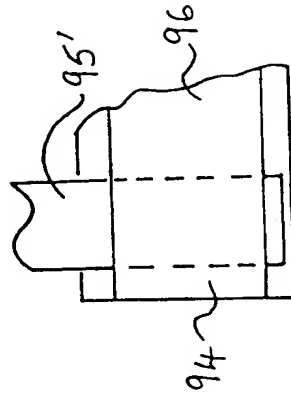
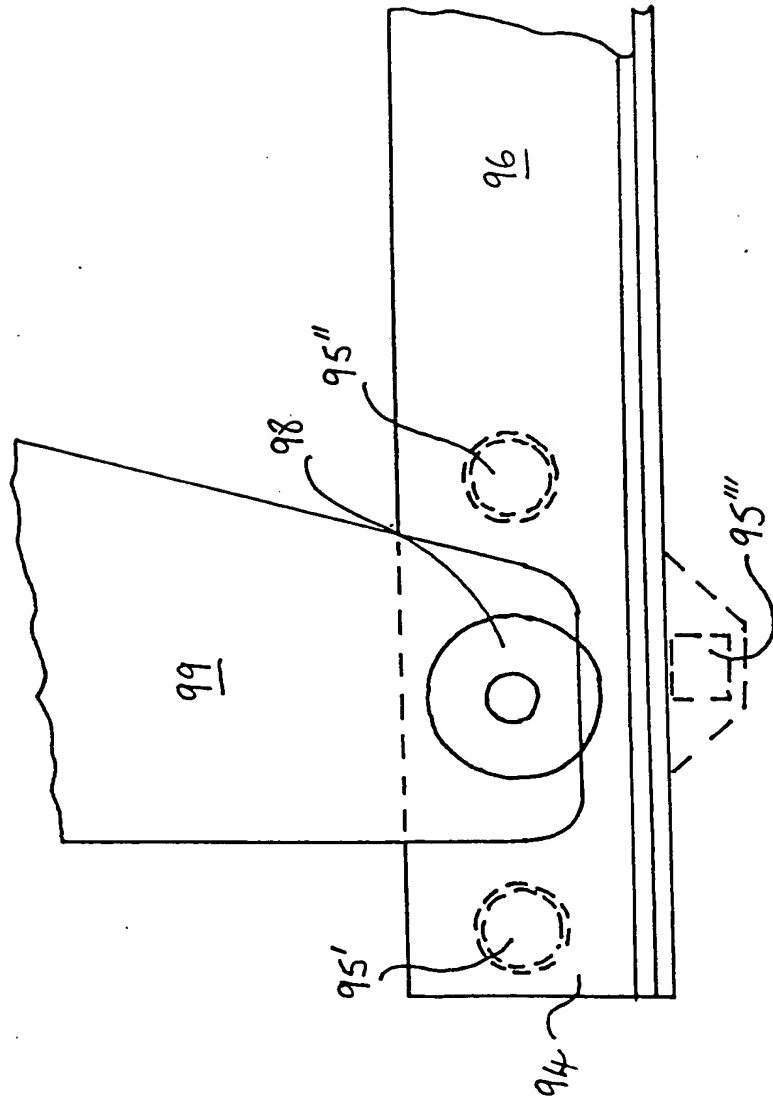


FIGURE 9B

FIGURE 10A

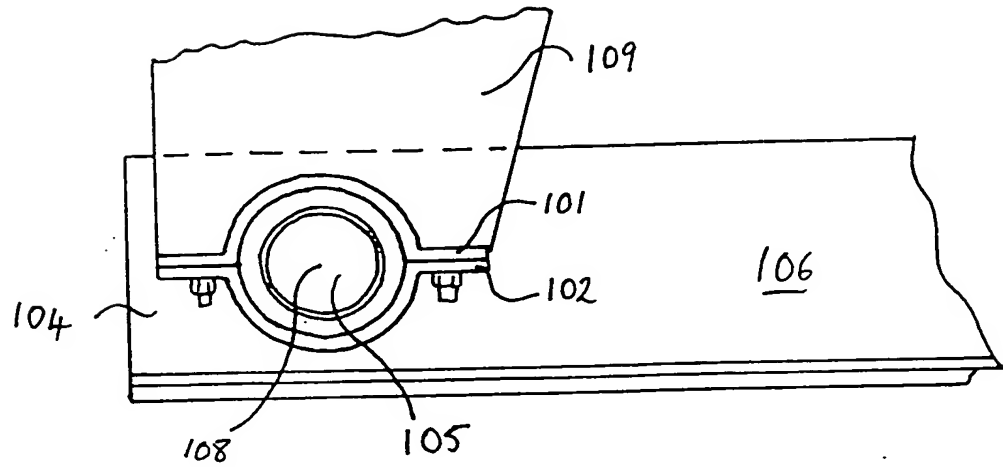


FIGURE 10B

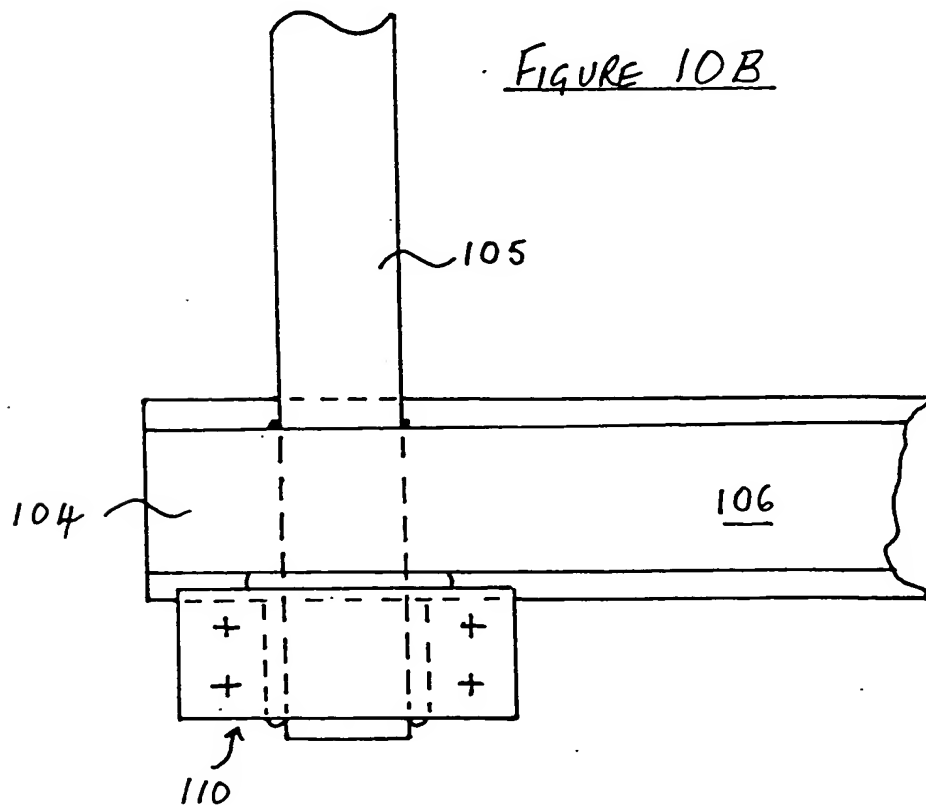


FIGURE 11A

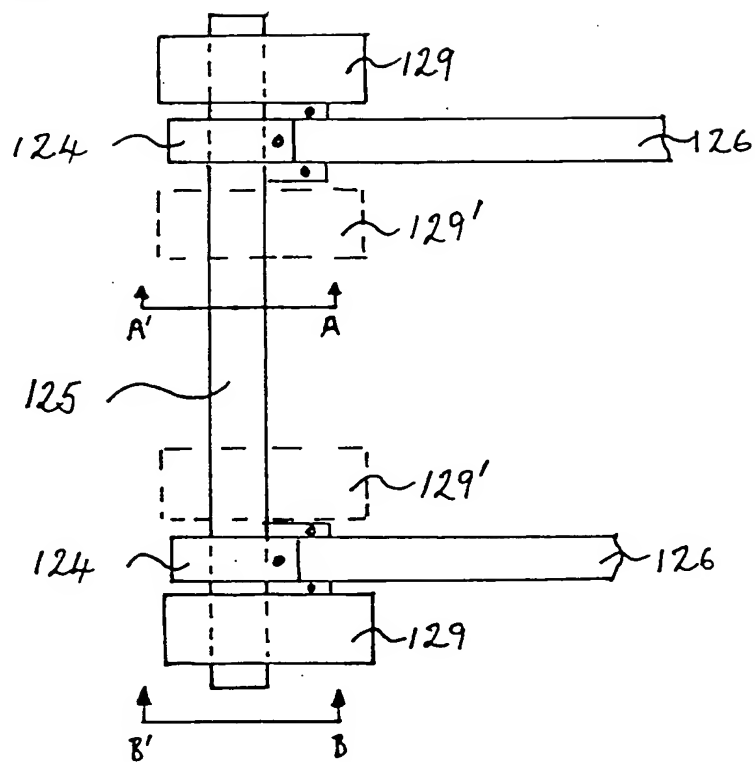


FIGURE 11B

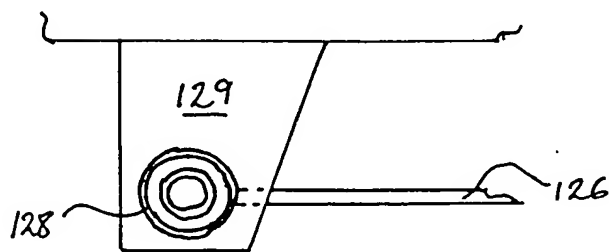


FIGURE 11C

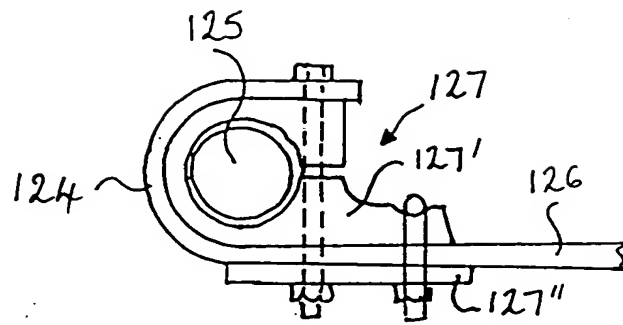


FIGURE 11D

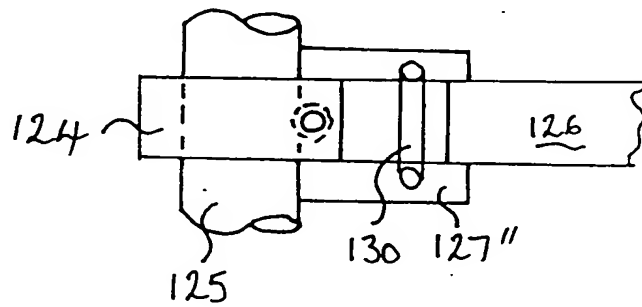
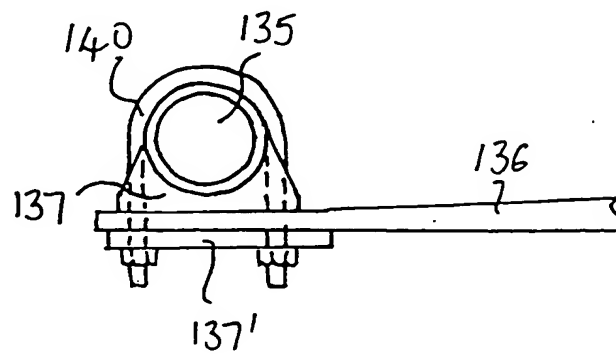


FIGURE 12



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